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Computer Modeling and Measurement of Metal Fragmentation in a Thermal Explosion Experiment†

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A computational and experimental analysis is given for the fragmentation of a well-characterized Aermet100 steel tube that initially confines an HMX-based explosive (LX-10). A Scaled Thermal Explosion Experiment (STEX) is performed in which the high explosive (HE) is heated at 1 ^{o}C/h until it explodes. Thermocouples are used to carefully control the temperature of the steel case and monitor the internal heating of the explosive as it decomposes. Strain gauges provide measurements of the tube expansion due to heating, pressurization from HE decomposition, and the rapid burn of the explosive. Metal fragment velocities are measured with velocity probes and a radar system. Captured fragments are used to establish size distributions and fracture characteristics.

Models are employed in an Arbitrary Lagrangian/Eulerian (ALE3D) computer code to calculate chemical, mechanical, and thermal effects through the heating, ignition, expansion, and fragmentation phases. The code is parallel, fully-coupled, and is able to handle strain rates that transition from structural to hydrodynamic conditions. A 4-step reaction model is used for the decomposition of the HE to product gases. The solid HE species are considered to be isotropic elastic-plastic materials with 7-term polynomial equations of state. A gamma law equation of state is applied to the decomposition gases. For the AerMet 100 steel, an isotropic elastic-plastic model with a Steinberg-Guinan hardening is used with a Gruneisen equation of state. The modified Johnson-Cook failure model is employed with a specified distribution of failure strains to provide for fragmentation. Comparisons are made for model and measured tube expansion rates along with fragment sizes and velocities.

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